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Nishikawa et al.

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(54) **LIGHTING DEVICE, LIGHT FIXTURE, AND VEHICLE**

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(51) **Int. Cl.**

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F21S 8/10	(2006.01)
B60Q 1/00	(2006.01)
H05B 33/08	(2006.01)

(52) **U.S. Cl.**

CPC ***F21S 48/00*** (2013.01); ***B60Q 1/0094*** (2013.01); ***H05B 33/0803*** (2013.01)

(58) **Field of Classification Search**

CPC F21V 23/026; F21V 17/08; F21S 48/00

See application file for complete search history.

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(57) **ABSTRACT**

A lighting device includes: a circuit board placed on a base; and a transformer provided in the circuit board. The transformer includes: a winding pattern formed on the circuit board; and a core having an outer leg portion. The circuit board has an outer leg insertion portion through which the outer leg portion of the core is inserted, and the circuit board and the base have therebetween a gap which is air space. The base and at least a lateral face of the outer leg portion are bonded together by a first resin that is insertable from the outer leg insertion portion.

12 Claims, 15 Drawing Sheets

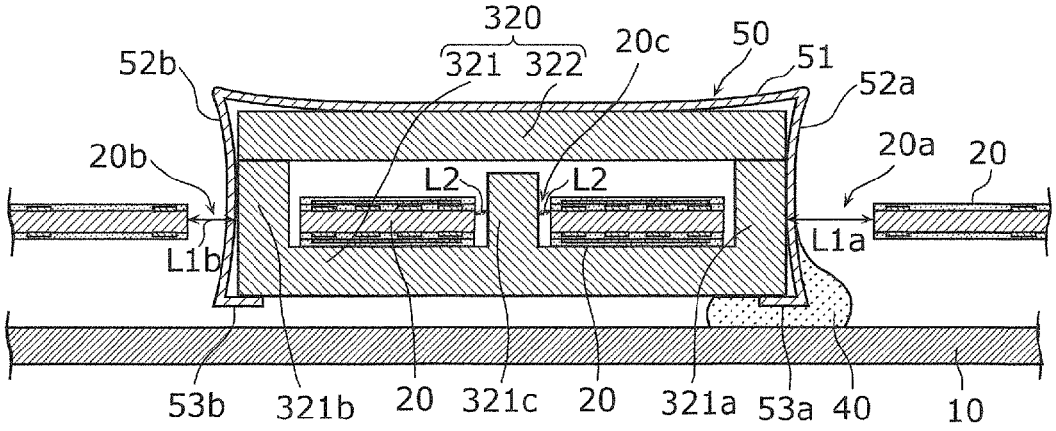


FIG. 1A

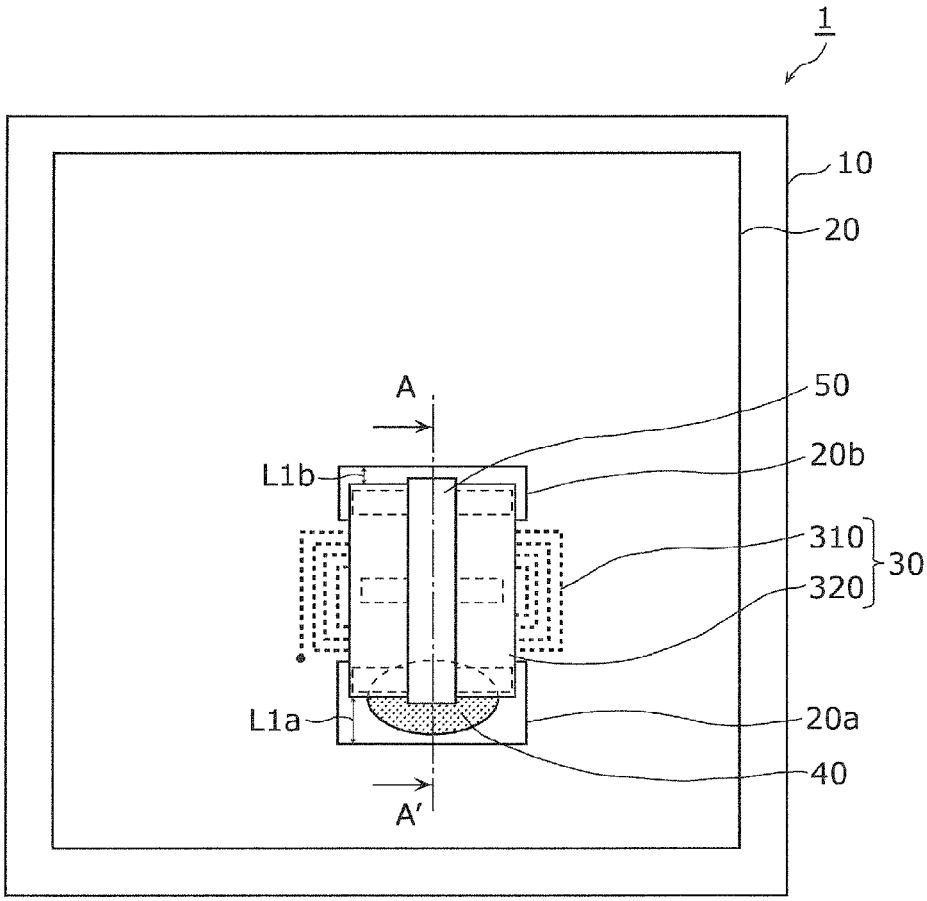

1
10
20
A
50
L1b
20b
310
320
30
L1a
20a
40
A'

FIG. 1B

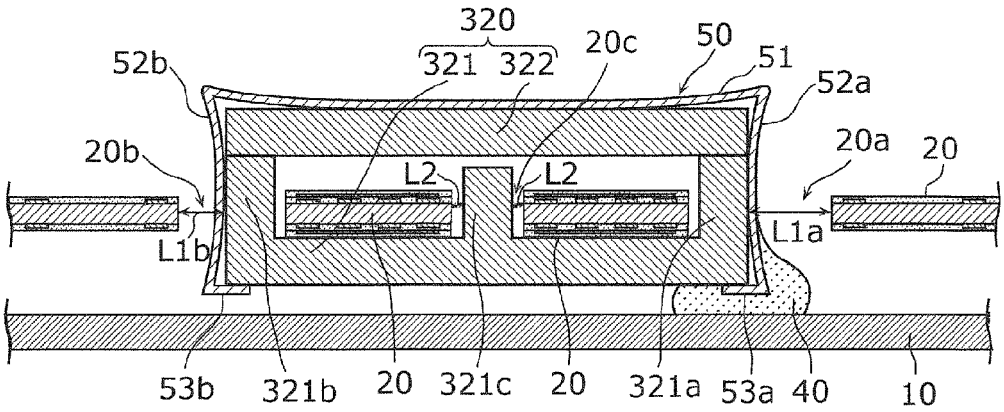

320
321 322
20c
50
51
52b
52a
20b
20a
20
L2
L2
L1b
L1a
53b
321b
20
321c
20
321a
53a
40
10

FIG. 2

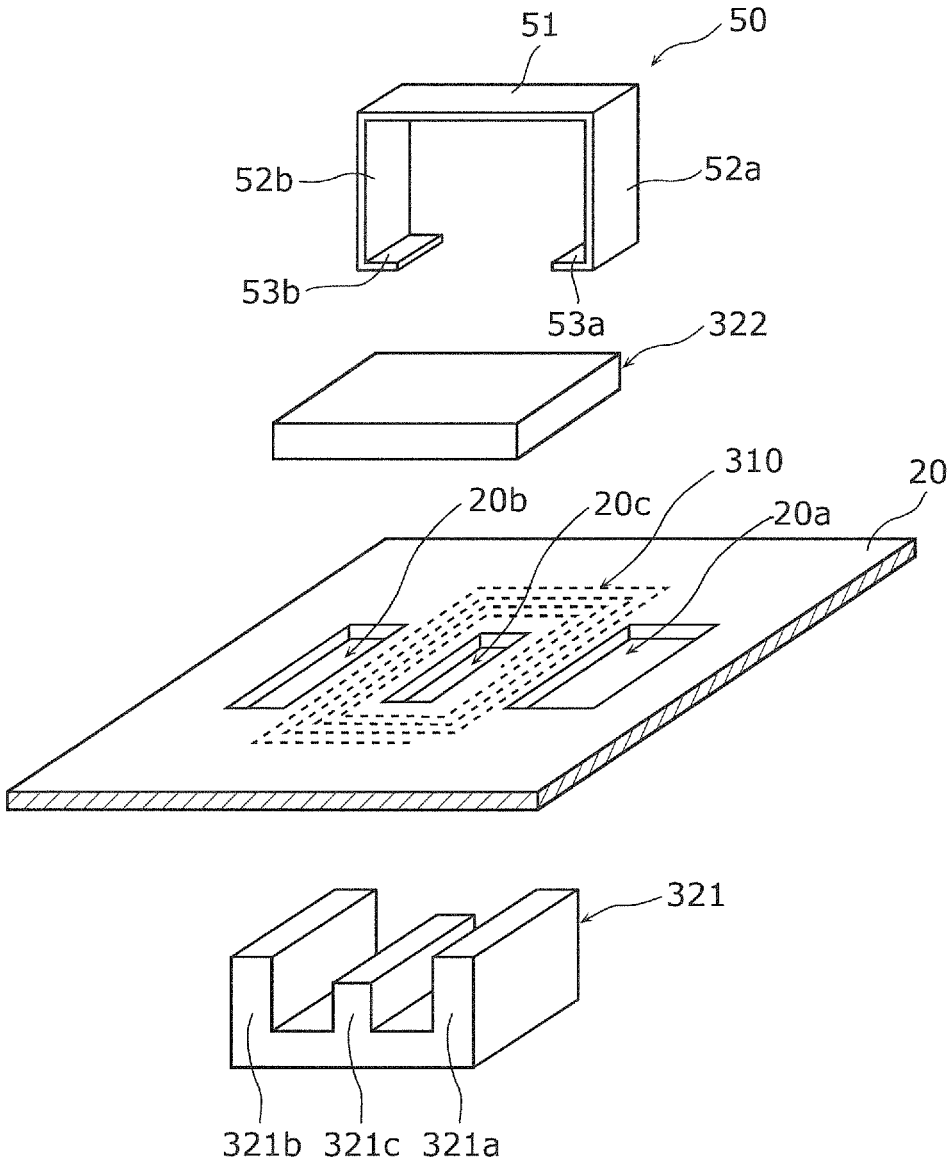


FIG. 3A

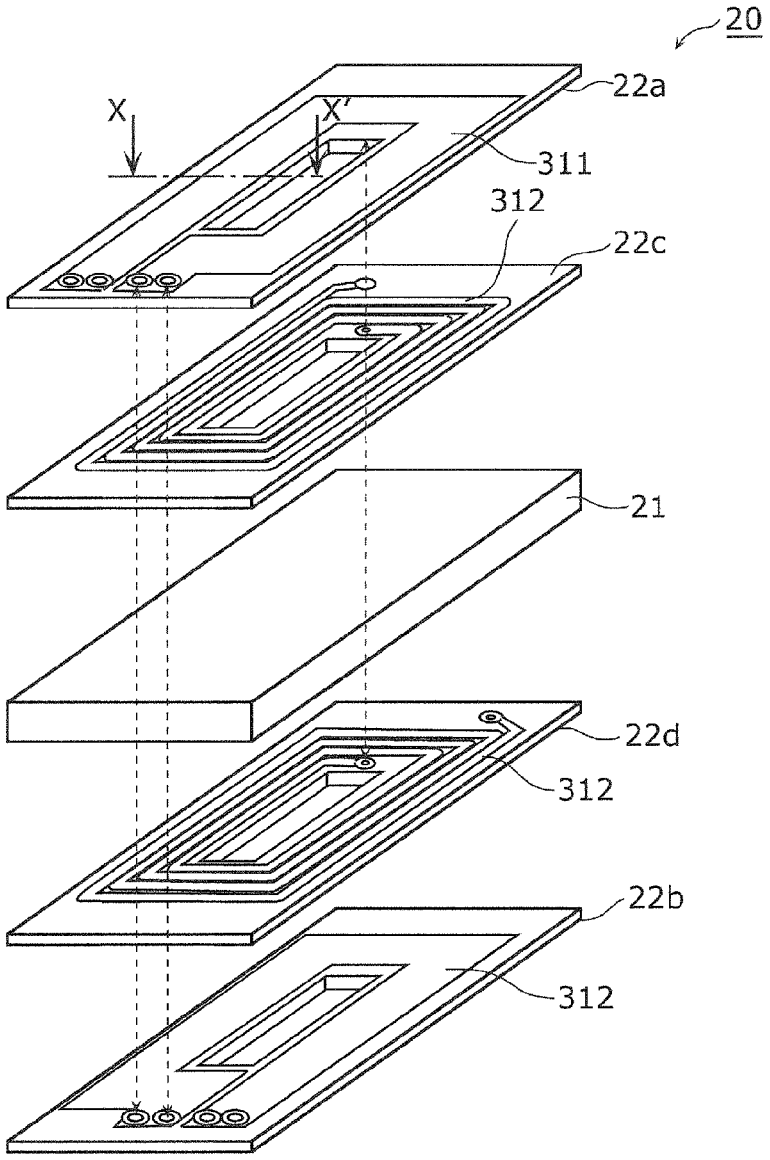

20
22a
X
X'
311
312
22c
21
22d
312
22b
312

FIG. 3B

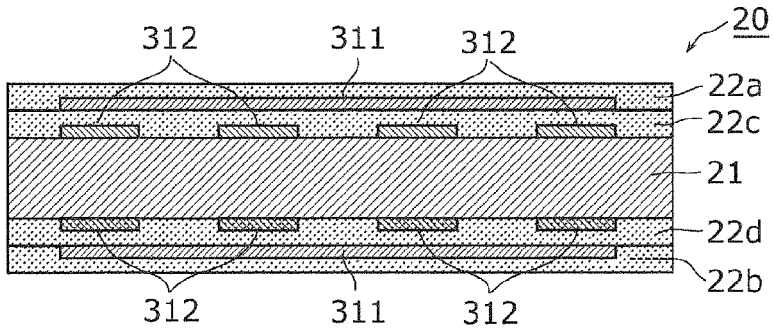

312
311
312
20
22a
22c
21
22d
22b
312
311
312

FIG. 4

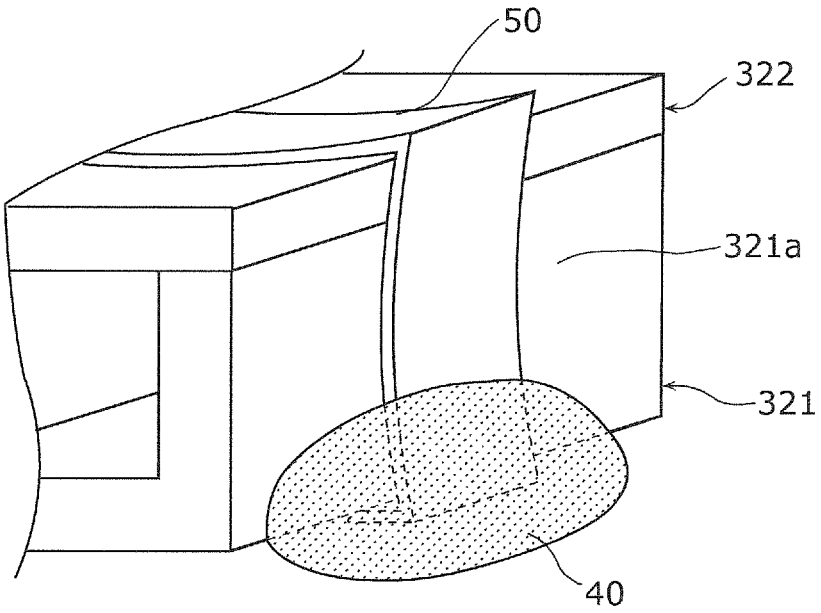


FIG. 5A

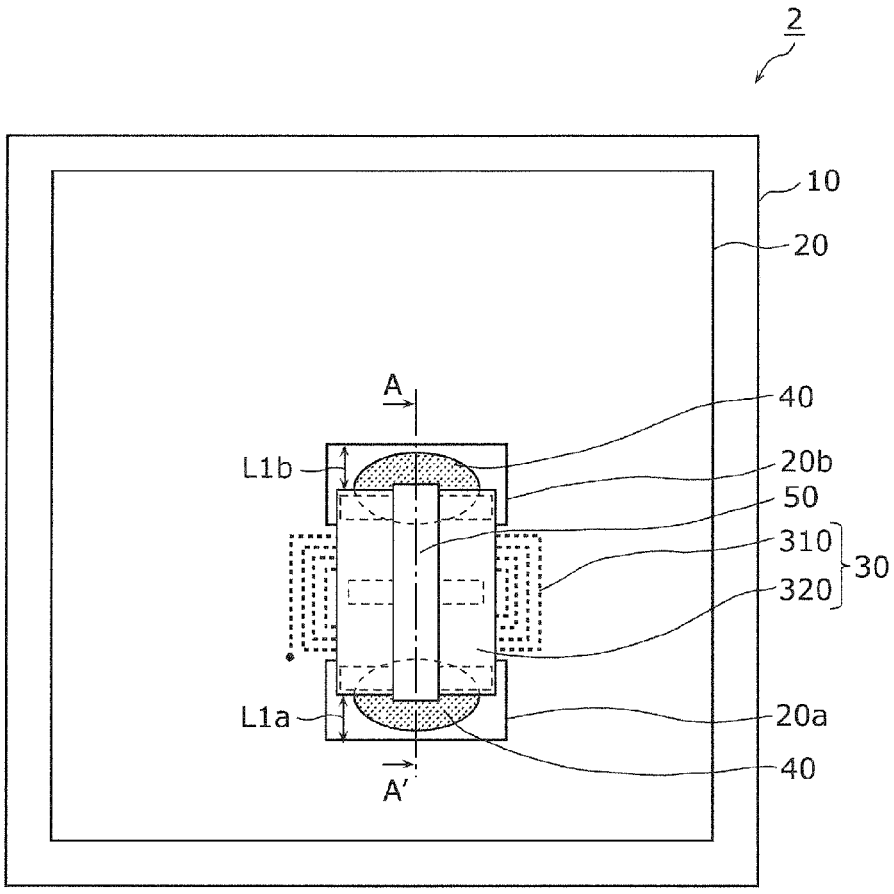

2
10
20
A
40
L1b
20b
50
310
30
320
L1a
20a
40
A'

FIG. 5B

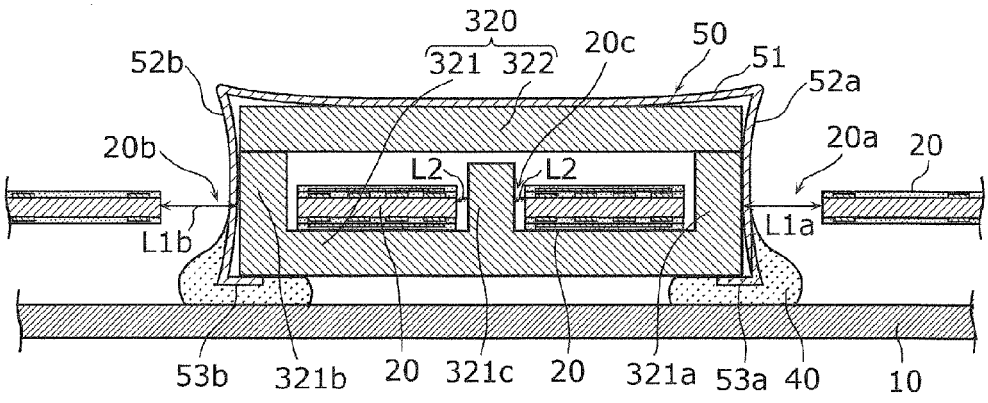

320
321 322
20c
50
51
52b
52a
20b
20a
20
L2
L2
L1b
L1a
53b
321b
20
321c
20
321a
53a
40
10

FIG. 6

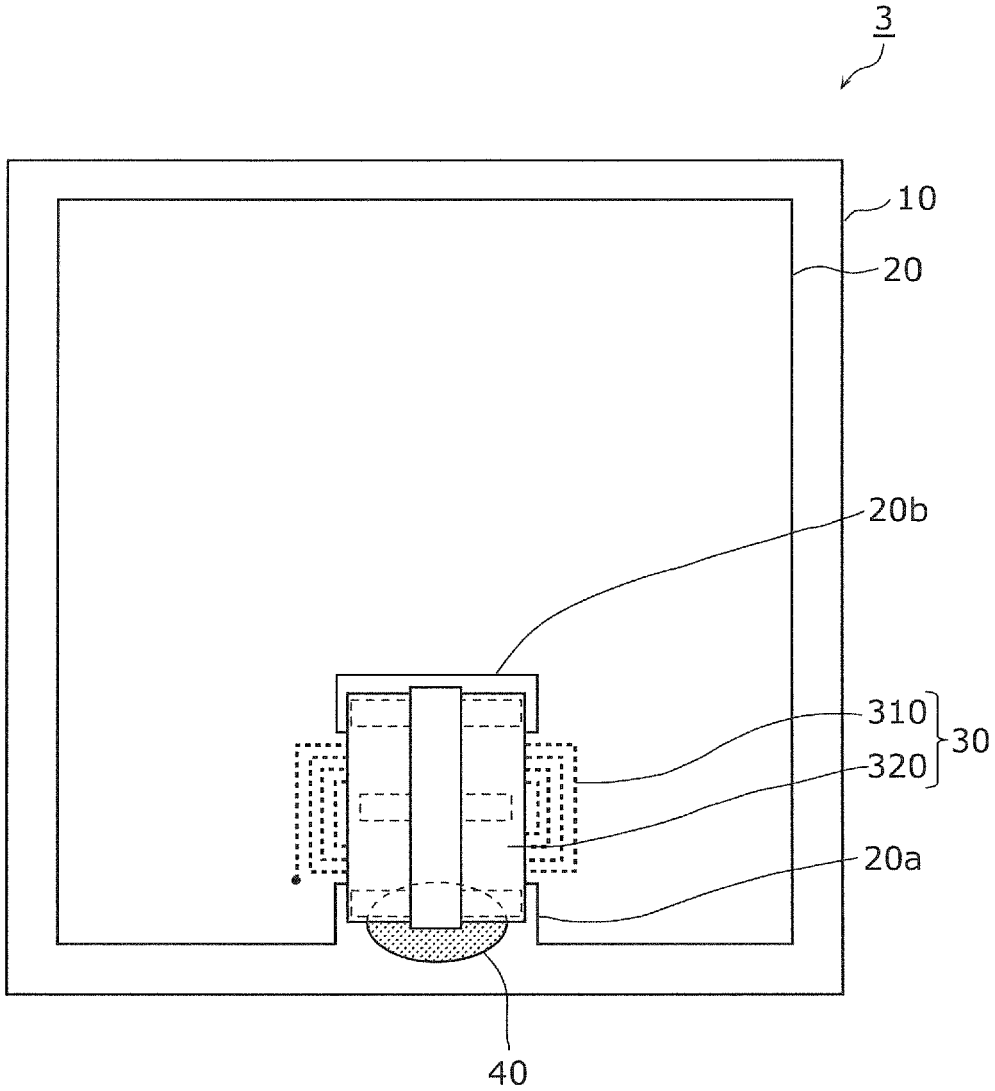


FIG. 7

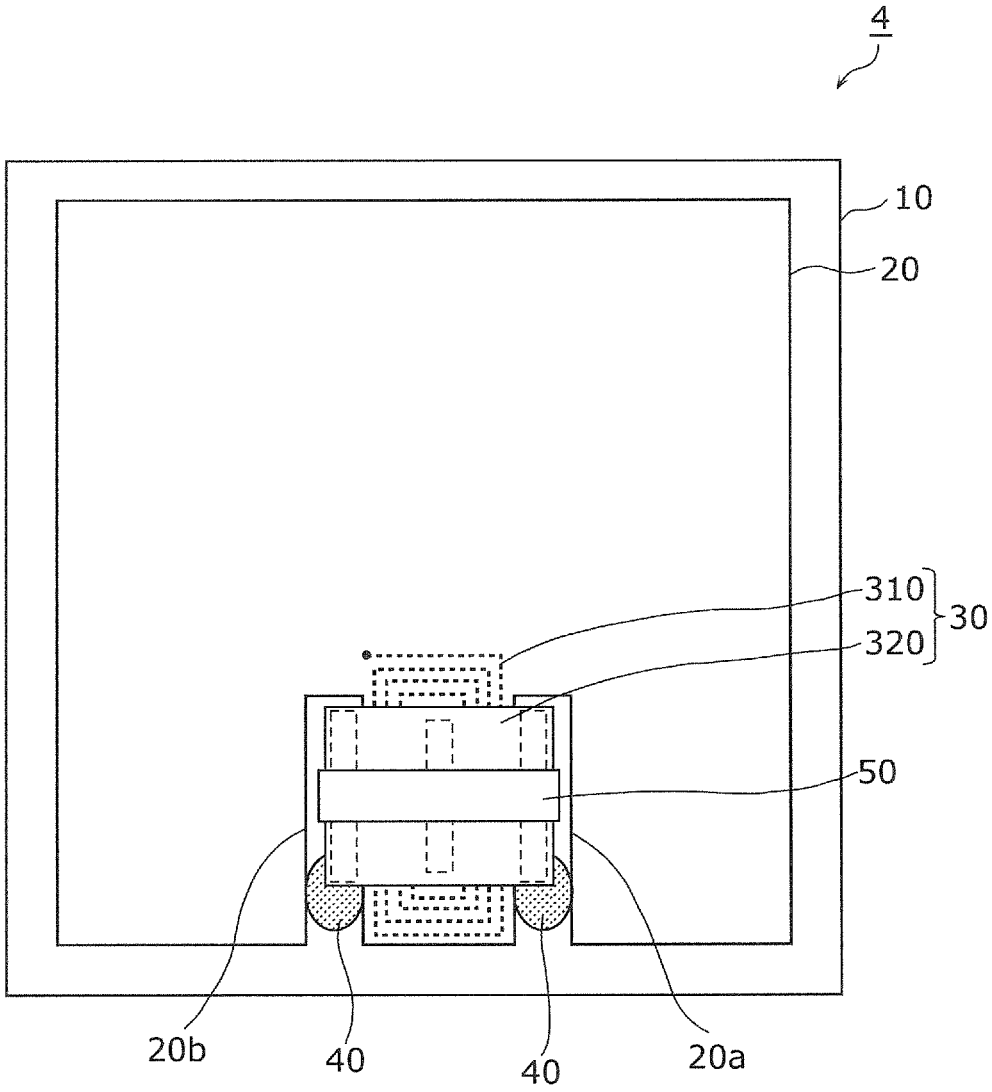


FIG. 8

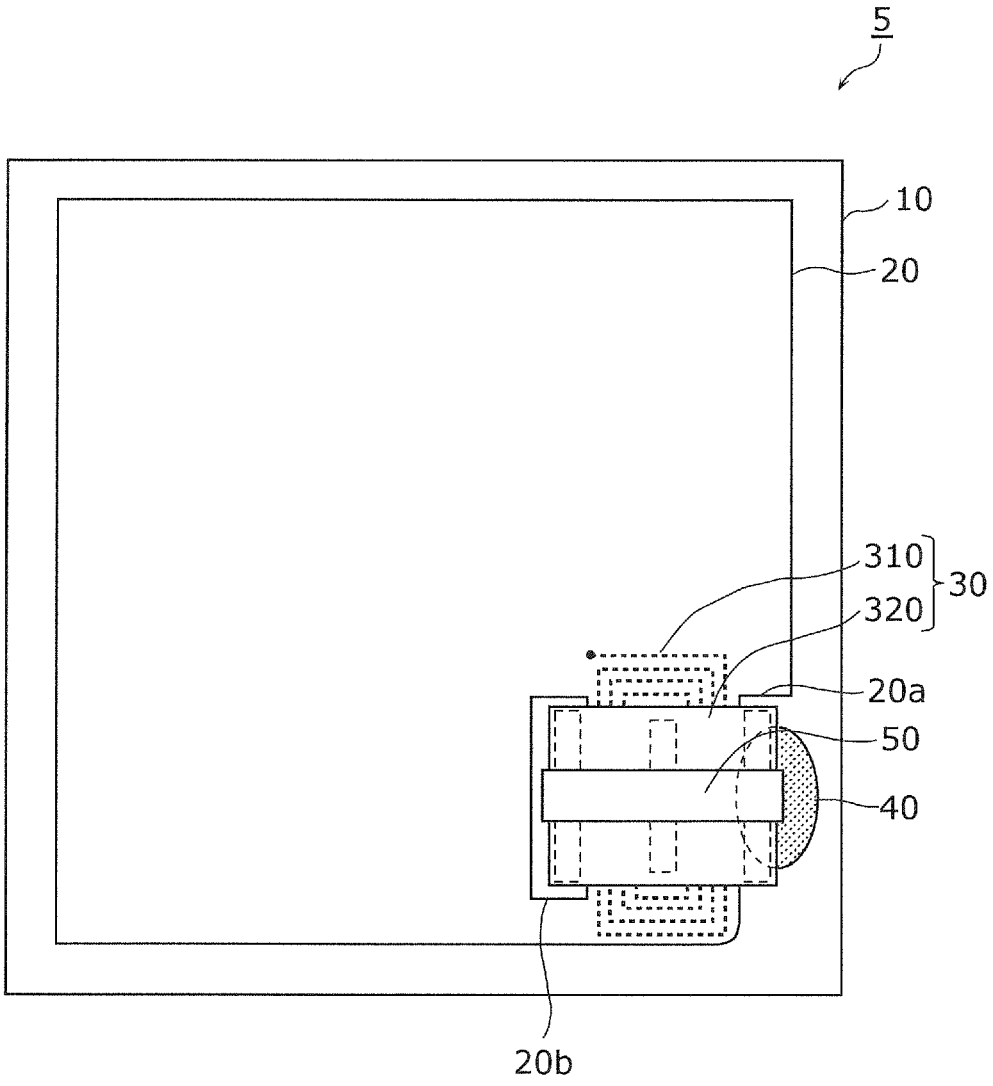


FIG. 9

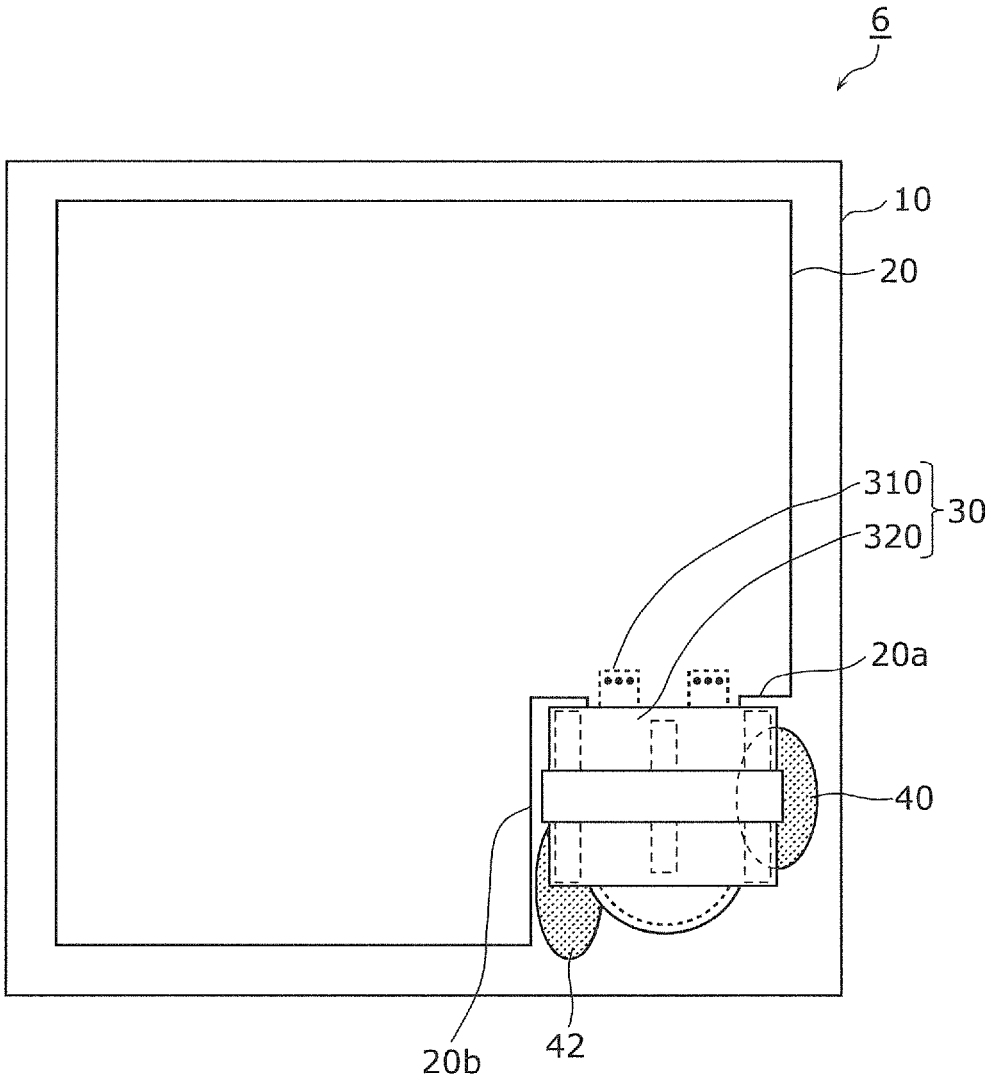


FIG. 10

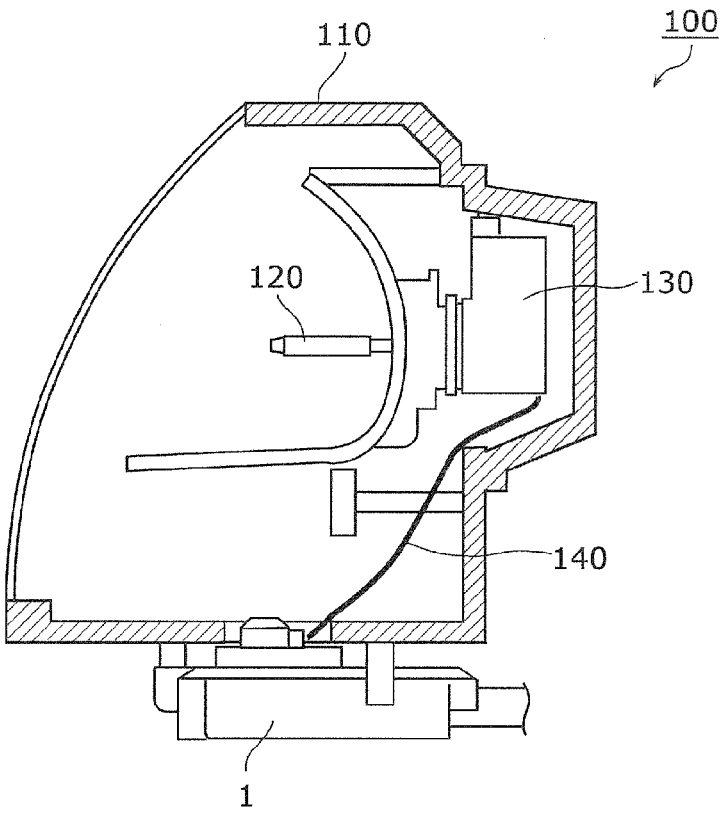

110
100
120
130
140
1

FIG. 11

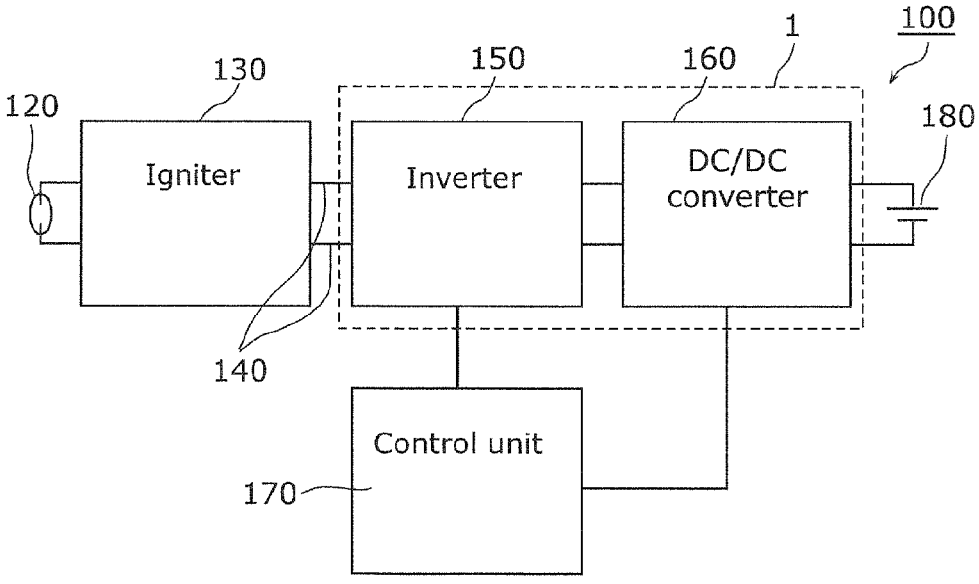

1
100
130
150
160
120
180
Igniter
Inverter
DC/DC converter
140
Control unit
170

FIG. 12

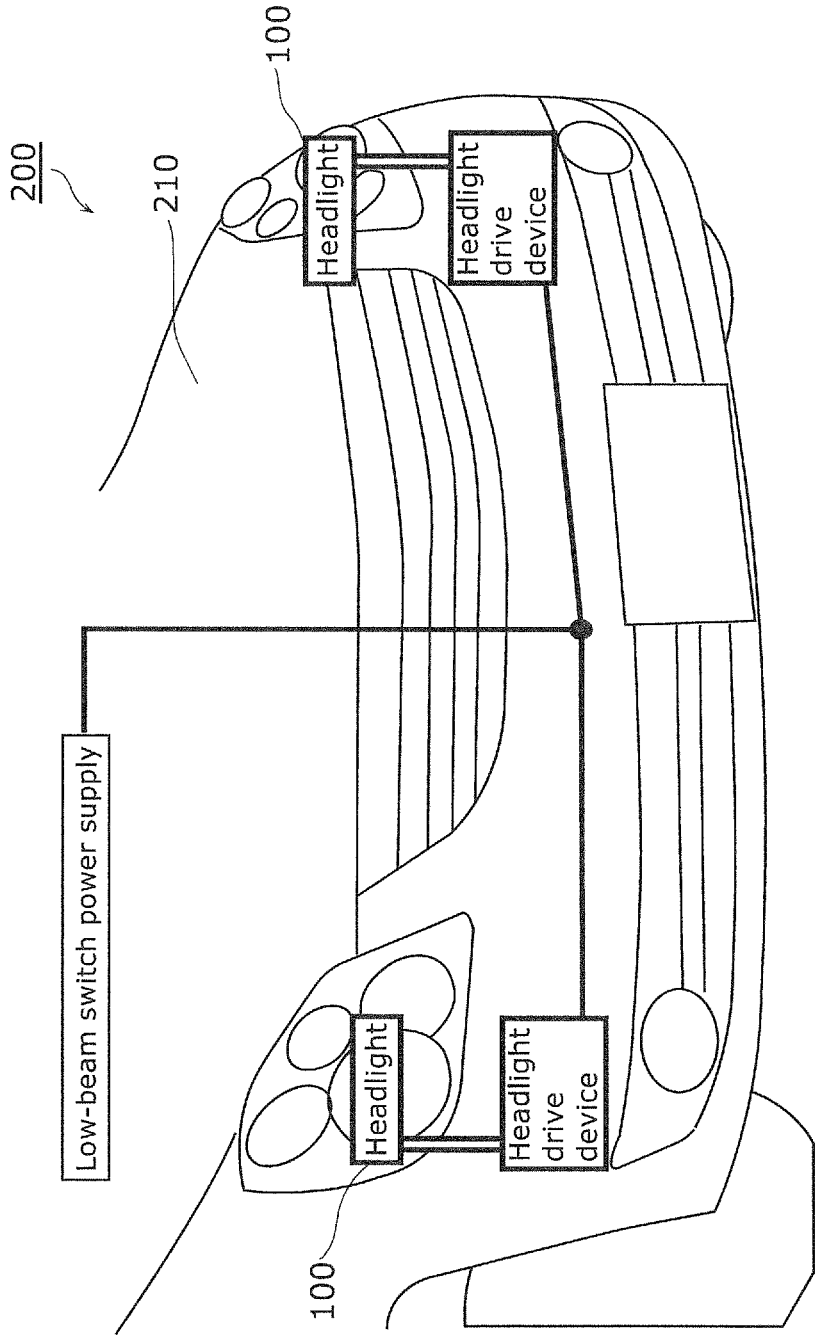

200
210
100
Headlight
Headlight drive device
Low-beam switch power supply
Headlight
Headlight drive device
100

FIG. 13A

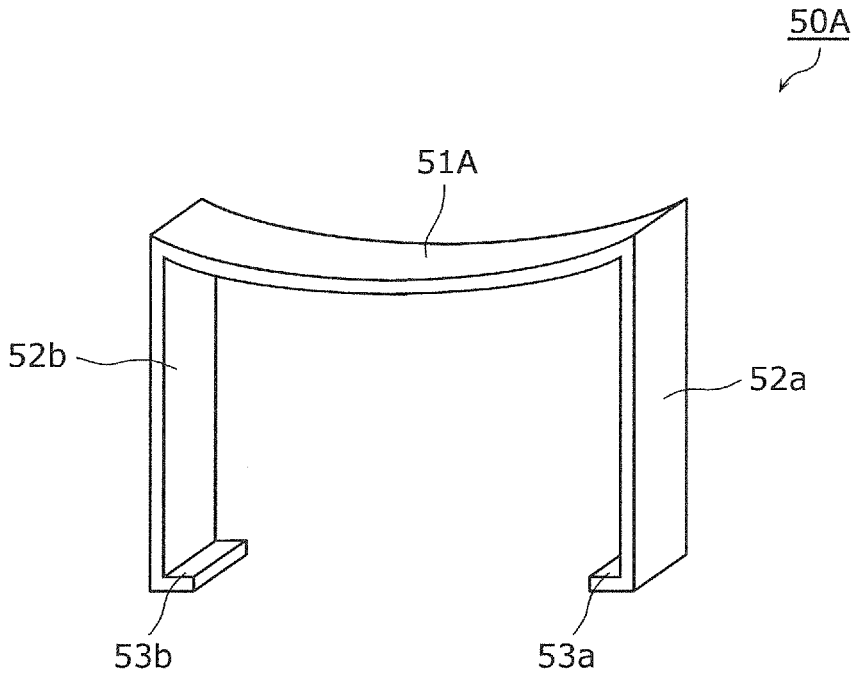


FIG. 13B

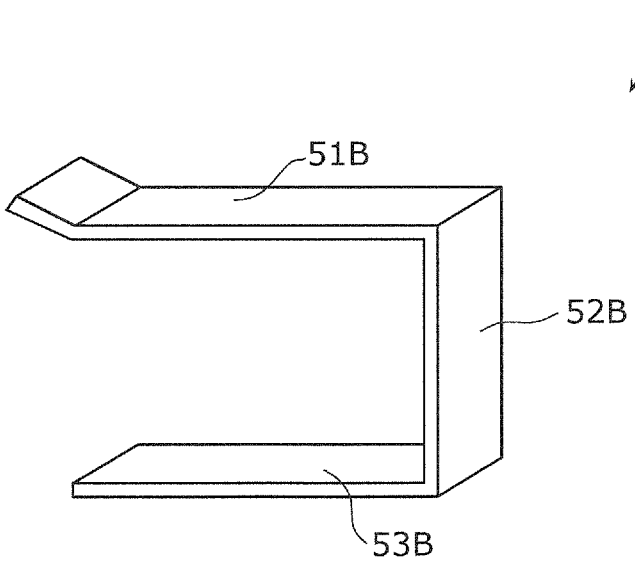


FIG. 14A

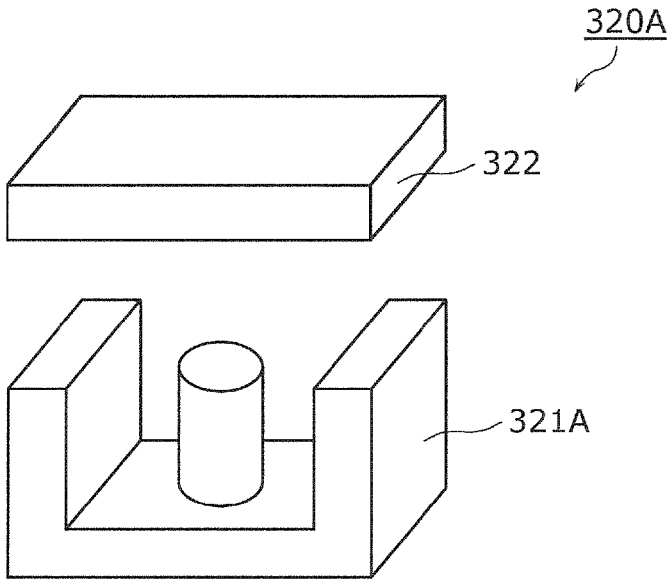


FIG. 14B

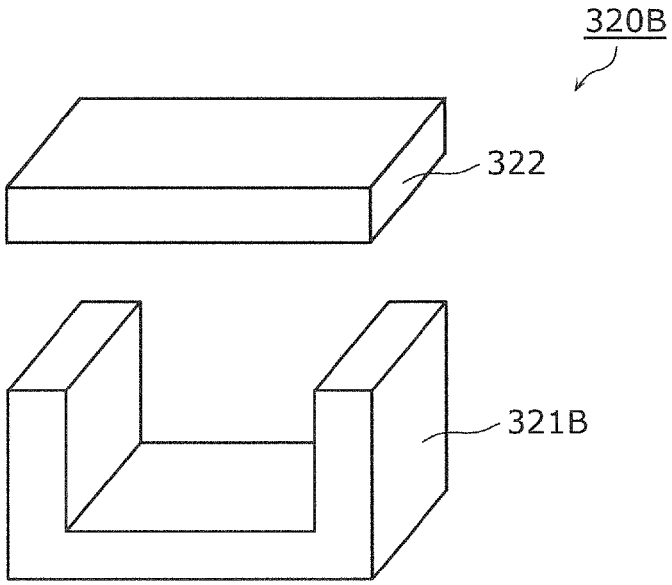


FIG. 15A

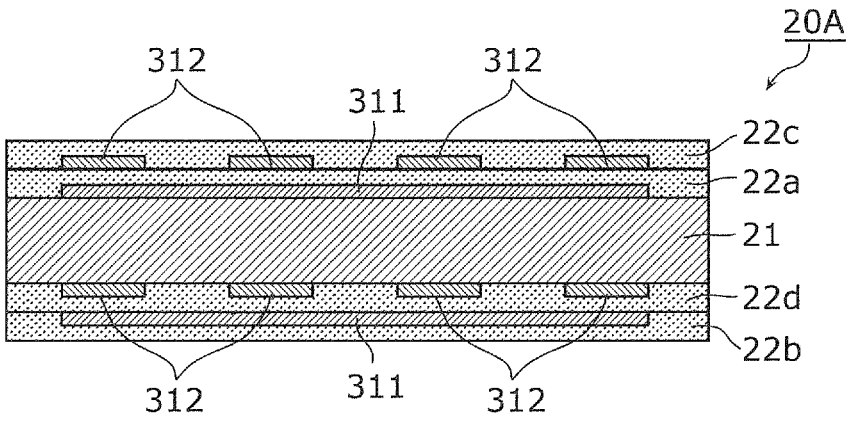


FIG. 15B

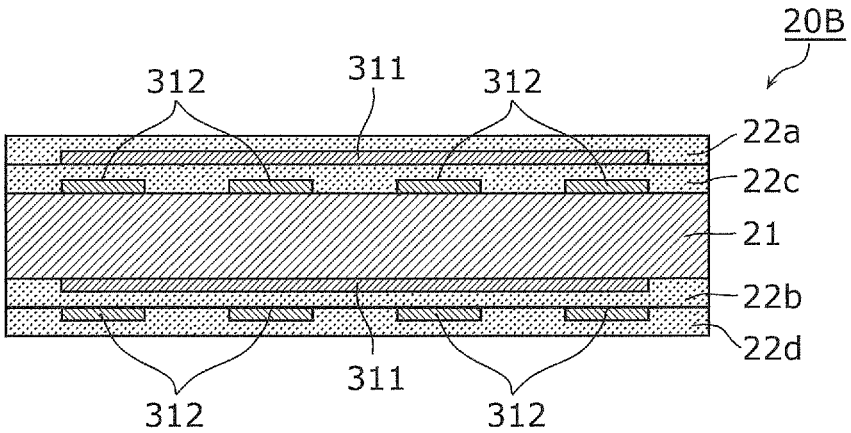


FIG. 16A

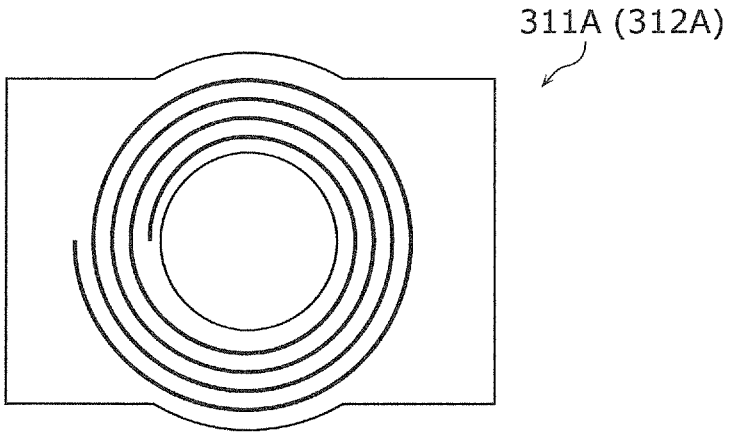


FIG. 16B

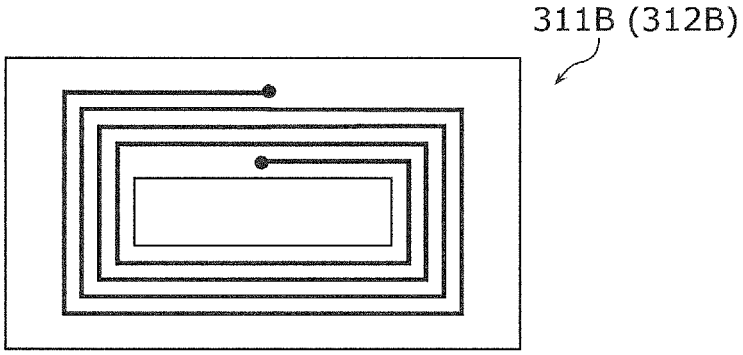
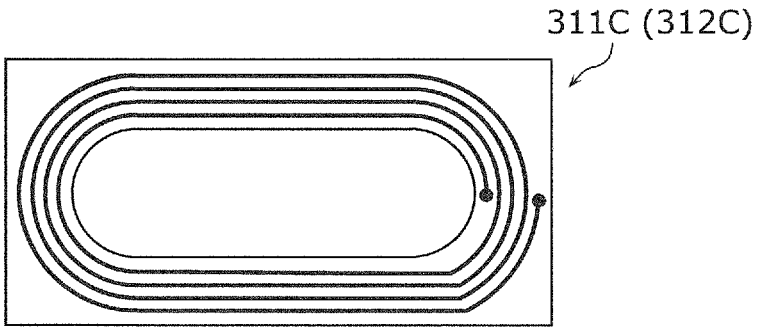


FIG. 16C



LIGHTING DEVICE, LIGHT FIXTURE, AND VEHICLE

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority of Japanese Patent Application Number 2013-182545, filed Sep. 3, 2013, the entire content of which is hereby incorporated by reference.

TECHNICAL FIELD

The disclosure relates to a lighting device, a light fixture including the same, and a vehicle including the light fixture.

BACKGROUND ART

Conventionally, a lighting device (lighting circuit) is used for controlling lighting of a light source. For example, in a light fixture, such as a headlight, in vehicles such as automobiles, a high intensity discharge (HID) lamp is provided as a light source, and a lighting device (ballast) is provided for controlling the lighting of the HID lamp.

As lighting devices are being miniaturized and made thinner, electronic components mounted onto circuit boards (printed boards) of lighting devices are also progressively being miniaturized and made thinner in recent years. For example, with regard to transformers which are one of the electronic components of lighting devices, there is a trend towards replacing transformers configured by winding copper wires around a bobbin with thin sheet transformers.

Sheet transformers include, for example, winding patterns such as a primary coil and a secondary coil formed on plural layers of a circuit board, and a core attached to the circuit board (see Unexamined Japanese Patent Application Publication No. 2010-178439).

SUMMARY

However, when a circuit board provided with a sheet transformer is to be bonded to a base such as a circuit case, there is the problem that, when the circuit board is placed on the base, it is difficult to bond the circuit board and the base.

The present invention is conceived in order to solve the aforementioned problem and has as an object to provide a lighting device which allows easy bonding of a circuit board and a base.

In order to achieve the aforementioned object, a lighting device according to an aspect of the present invention includes: a circuit board placed on a base; and a transformer provided in the circuit board, wherein the transformer includes a winding pattern and a core, the winding pattern being formed on the circuit board, and the core having an outer leg portion, the circuit board has an outer leg insertion portion through which the outer leg portion of the core is inserted, the circuit board and the base have therebetween a gap which is air space, and the base and at least a lateral face of the outer leg portion are bonded together by a first resin that is insertable from the outer leg insertion portion.

Furthermore, in a lighting device according to an aspect of the present invention, the outer leg portion may consist of a pair of outer leg portions, the outer leg insertion portion may consist of a pair of outer leg insertion portions through which the pair of outer leg portions are respectively inserted, and the first resin may bond together the base and a surface of one outer leg portion of the pair of outer leg portions, and may be disposed on a surface of the core, from the one outer leg portion to a point up to an other outer leg portion of the pair of outer leg portions.

In addition, in a lighting device according to an aspect of the present invention, the core may have a central leg portion located between the pair of outer leg portions, and the first resin may be disposed on the surface of the core, from the one outer leg portion to a point up to the central leg portion.

Furthermore, in a lighting device according to an aspect of the present invention, the base and a lateral face of the other outer leg portion may be bonded together by a second resin that is insertable from one of the pair of outer leg insertion portions which corresponds to the other outer leg portion, and the second resin may be disposed on the surface of the core, from the other outer leg portion to a point up to the one outer leg portion.

Furthermore, in a lighting apparatus according to an aspect of the present invention, the outer leg insertion portion may be a hole penetrating through the circuit board.

Furthermore, in a lighting apparatus according to an aspect of the present invention, the outer leg insertion portion may be a notch formed by cutting out a portion of an outer edge of the circuit board.

Furthermore, in a lighting apparatus according to an aspect of the present invention, the notch may be formed by cutting out a corner portion of the circuit board.

Furthermore, in a lighting apparatus according to an aspect of the present invention, the first resin may be further disposed between a bottom face of the core and a top face of the base.

Furthermore, a light fixture according to an aspect of the present invention includes: any one of the above-described lighting devices; a housing; and a light source housed inside the housing and whose lighting is controlled by the lighting device.

Furthermore, a vehicle according to an aspect of the present invention includes: the above-described light fixture; and a vehicle body.

According to the present invention, the circuit board and the base can be bonded together easily.

BRIEF DESCRIPTION OF THE DRAWINGS

The figures depict one or more implementations in accordance with the present teaching, by way of examples only, not by way of limitations. In the figures, like reference numerals refer to the same or similar elements.

FIG. **1**A is a plan view of a lighting device according to Embodiment 1 of the present invention.

FIG. **1**B is a cross-sectional view of a lighting device according to Embodiment 1 of the present invention at line A-A' in FIG. **1**A.

FIG. **2** is an exploded prospective view of a vicinity of a transformer in a lighting device according to Embodiment 1 of the present invention.

FIG. **3**A is an exploded view of a circuit board in a lighting device according to Embodiment 1 of the present invention.

FIG. **3**B is a cross-sectional view of a circuit board in a lighting device according to Embodiment 1 of the present invention at line X-X' in FIG. **3**A.

FIG. **4** is a perspective view of a configuration of a vicinity of a resin in a lighting device according to Embodiment 1 of the present invention.

FIG. **5**A is a plan view of a lighting device according to Modification 1 of Embodiment 1 of the present invention.

FIG. **5**B is a cross-sectional view of a lighting device according to Modification 1 of Embodiment 1 of the present invention at line A-A' in FIG. **5**A.

FIG. **6** is plan view of a lighting device according to Modification 2 of Embodiment 1 of the present invention.

FIG. **7** is a plan view of a lighting device according to Modification 2 of Embodiment 1 of the present invention.

FIG. **8** is a plan view of a lighting device according to Modification 3 of Embodiment 1 of the present invention.

FIG. **9** is plan view of a lighting device according to Modification 3 of Embodiment 1 of the present invention.

FIG. **10** is a cross-sectional view of a light fixture according to Embodiment 2 of the present invention.

FIG. **11** is a block diagram illustrating a configuration of a light fixture according to Embodiment 2 of the present invention.

FIG. **12** is a diagram showing an outline configuration of a vehicle according to Embodiment 3 of the present invention.

FIG. **13**A is diagram illustrating another configuration of a spring component in a lighting device according to Embodiment 1 of the present invention.

FIG. **13**B is diagram illustrating yet another configuration of a spring component in a lighting device according to Embodiment 1 of the present invention.

FIG. **14**A is a diagram illustrating another configuration of a core in a lighting device according to Embodiment 1 of the present invention.

FIG. **14**B is a diagram illustrating yet another configuration of a core in a lighting device according to Embodiment 1 of the present invention.

FIG. **15**A is a diagram illustrating another configuration of a circuit board in a lighting device according to Embodiment 1 of the present invention.

FIG. **15**B is a diagram illustrating yet another configuration of a circuit board in a lighting device according to Embodiment 1 of the present invention.

FIG. **16**A is diagram illustrating another configuration of a winding pattern in a lighting device according to Embodiment 1 of the present invention.

FIG. **16**B is diagram illustrating yet another configuration of a winding pattern in a lighting device according to Embodiment 1 of the present invention.

FIG. **16**C is diagram illustrating still another configuration of a winding pattern in a lighting device according to Embodiment 1 of the present invention.

DETAILED DESCRIPTION

Hereinafter, exemplary embodiments of the present invention will be described with reference to the drawings. It should be noted that each of the subsequently-described embodiments show a specific preferred example of the present invention. Therefore, numerical values, shapes, materials, structural components, the arrangement and connection of the structural components, as well as steps and the sequence of the steps, etc. shown in the following exemplary embodiments are mere examples, and are not intended to limit the scope of the present invention. Furthermore, among the structural components in the following exemplary embodiment, components not recited in any one of the independent claims which indicate the broadest concepts of the present invention are described as arbitrary structural components.

It should be noted that the respective figures are schematic diagrams and are not necessarily precise illustrations. Furthermore, in the respective figures, substantially identical components are assigned the same reference signs, and overlapping description is omitted or simplified.

Embodiment 1

First, a configuration of a lighting device **1** according to Embodiment 1 of the present invention will be described using FIG. **1**A, FIG. **1**B, and FIG. **2**. FIG. **1**A is a plan view of the lighting device **1** according to Embodiment 1 of the present invention. FIG. **1**B is a cross-sectional view of the lighting device at line A-A' in FIG. **1**A. FIG. **2** is an exploded prospective view of the vicinity of a transformer in the lighting device **1** according to Embodiment 1 of the present invention. It should be noted that, in FIG. **1**A, only the configuration in the vicinity of the transformer is illustrated, and electronic components other than the transformer are omitted.

The lighting device according to this embodiment is a lighting device (ballast) for turning ON an HID lamp such as a metal halide lamp used as a light source of a vehicle light fixture for example, and includes, as illustrated in FIG. **1**A, FIG. **1**B, and FIG. **2**, a base **10**, a circuit board **20** placed on the base **10**, a transformer **30** provided in the circuit board **20**, and a resin **40** for fixing the core of the transformer **30** to the base **10**. In addition, the lighting device **1** includes a spring component **50** which secures in an integrated manner a core **320** which consists of plural parts.

Hereinafter, the respective constituent components of the lighting device **1** will be described in detail.

(Base)

The base **10** is an placement base for placing the circuit board **20**, and is for example a circuit case (housing). The base **10**, which is a circuit case, is configured of, for example, a box-shaped case body and a case cover which is a cover of the case body. In this case, the circuit board **20** is placed on the bottom of the case body.

The base **10** can be formed using a metal material such as aluminum or stainless steel. For example, a base **10** having a predetermined shape can be formed by performing press work on a metal plate.

It should be noted that the material of the base **10** is not limited to a metal material, and a resin material may be used. Furthermore, the shape of the base **10** is not limited to being box-like, and may be board-like, and so on.

(Circuit Board)

As illustrated in FIG. **1**B, the circuit board **20** is disposed separated from the base **10** by a gap. In other words, a gap, which is air space, is present between the circuit board **20** and the base **10**. This gap is not filled-in by the resin **40**. By placing the circuit board **20** on a projecting portion (not shown) which projects from the circuit board **20**-side of the base **10** for example, a gap can be provided between the circuit board **20** and portions of the base **10** other than the projecting portion. It should be noted that, aside from the projecting portion provided in the base **10**, a spacer (not shown) which is a different component from the base **10** may be used. Furthermore, the projecting portion or spacer may be provided at any position between the base **10** and the circuit board **20**. For example, when provided near the vicinity of the outer edge of the circuit board **20**, the projecting portion or spacer does not interfere with a later-described electronic components to be mounted on the circuit board **20**, thereby allowing effective space utilization.

Furthermore, the gap (air space) between the circuit board **20** and the base **10** can be provided without using a projecting portion or a spacer. For example, when the resin **40** flows out between the circuit board **20** and the base **10**, a gap is provided between the circuit board **20** and the base **10**. In other words, there are cases where the resin **40** is present between the

circuit board **20** and the base **10**, and so it is not necessarily true that the resin **40** is not formed between the circuit board **20** and the base **10**. However, even when the resin **40** flows out between the circuit board **20** and the base **10**, the entire area between the circuit board **20** and the base **10** is not filled in by the resin **40**, and at least a gap (air space) where the resin **40** is absent is present between the circuit board **20** and the base **10**.

Electronic components including the transformer **30** are mounted on the circuit board **20**. Furthermore, the circuit board **20** is a printed wiring board, and metal wiring for electrically connecting the respective electronic components is formed by patterning on the surface of the circuit board **20**.

Aside from the transformer **30**, the electronic components include, for example, a resistor, a capacitor, a coil, a transistor, or a diode.

The transformer **30** and the electronic components make up an electronic circuit such as a DC/DC converter or an inverter, for controlling the lighting of an HID lamp.

The circuit board **20** is provided with insertion portions through which leg portions provided in a first core **321** of the core **320** are inserted. Specifically, as illustrated in FIG. **2**, the circuit board **20** has a first outer leg insertion portion **20***a* through which a first outer leg portion **321***a* is inserted, a second outer leg insertion portion **20***b* through which a second outer leg portion **321***b* is inserted, and central leg insertion portion **20***c* through which a central leg portion **321***c* is inserted. In other words, a pair of insertion portions (the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*) and the central leg insertion portion **20***c* provided between the pair of insertion portions are provided in the circuit board **20**.

In this embodiment, each of the first outer leg insertion portion **20***a*, the second outer leg insertion portion **20***b*, and the central leg insertion portion **20***c* is a through hole which penetrates through the circuit board **20** in the thickness direction. The through holes have a rectangular plan view shape, and the lengthwise and crosswise dimensions of the opening of the through holes are such that the edge of each through hole does not come into contact with a corresponding leg portion when the respective leg portions of the first core **321** are inserted.

It should be noted that the shape of the opening of the through hole of the first outer leg insertion portion **20***a*, the second outer leg insertion portion **20***b*, and the shape of the central leg insertion portion **20***c* is not limited to being rectangular, and may be circular, oval, or elliptic. Furthermore, it is preferable to match the shape of the openings of the through holes to the shape of the leg portions of the first core **321**.

As illustrated in FIG. **1**A and FIG. **1**B, the base **10** and the lateral face of the first outer leg portion **321***a* of the first core **321** are bonded together in the first outer leg insertion portion **20***a* by the resin **40** having an adhesive function.

Here, width of the opening of the first outer leg insertion portion **20***a* is of a size which allows the resin **40**, which is an adhesive, to be applied by being inserted from the first outer leg insertion portion **20***a*, even after the core **320** (the first core **321**) is attached to the circuit board **20**. Specifically, as illustrated in FIG. **1**A and FIG. **1**B, the width of the opening of the first outer leg insertion portion **20***a* is set so that a clearance L**1***a* between the circuit board **20** and the lateral face of the first outer leg portion **321***a* in the first outer leg insertion portion **20***a* is larger than a clearance L**2** between the circuit board **20** and the central leg portion **321***c* in the central leg insertion portion **20***c*.

Accordingly, the resin **40** can be easily applied to the bottom portion of the first core **321** via the first outer leg insertion portion **20***a* even after the circuit board **20**, to which the first core **321** and the second core **322** are secured by the spring component **50**, is placed on the base **10**. For example, when the resin **40** is to be applied using a nozzle, it is preferable that the first outer leg insertion portion **20***a* be of a size which allows insertion of the nozzle.

It should be noted that, for the second outer leg insertion portion **20***b*, a clearance L**1***b* between the circuit board **20** and the lateral face of the second outer leg portion **321***b* in the second outer leg insertion portion **20***b* is smaller than the clearance L**1***a* between the circuit board **20** and the lateral face of the first outer leg portion **321***a* in the first outer leg insertion portion **20***a*.

Furthermore, the circuit board **20** is formed using a material such a glass epoxy such as FR-4, and is a mufti-layer substrate which includes a flat coil and is formed by sandwiching an insulating material between conductors.

Here, a detailed configuration of the circuit board **20** in this embodiment will be described using FIG. **3**A and FIG. **3**B. FIG. **3**A is an exploded view of a circuit board in a lighting device according to Embodiment 1 of the present invention. FIG. **3**B is a cross-sectional view of the circuit board at line X-X' in FIG. **3**A.

As illustrated in FIG. **3**A and FIG. **3**B, the circuit board **20** is, for example, a coil board made from four laminated substrates, and includes a core substrate **21**, the four layers of a first layer **22***a* to a fourth layer **22***d* which are formed to sandwich the core substrate **21** and are made of an insulating material, and a primary coil **311** and a secondary coil **312** which form winding patterns **310** of flat coil and are made of a conductor.

The core substrate **21** is formed, for example, by forming a heat-resistant glass substrate epoxy resin into a board-shape.

The first layer **22***a* and the second layer **22***b* make up the outermost layers of the circuit board **22**, and are resists formed by curing a thermosetting epoxy resin, for example. The first layer **22***a* and the second layer **22***b* are formed to cover the third layer **22***c* and the fourth layer **22***d*, respectively. The third layer **22***c* and the fourth layer **22***d* are formed to sandwich the core substrate **21**, and are prepregs of glass fiber or the like which are interwoven into a mesh for example.

The primary coil **311** and the secondary coil **312** are configured by turning, for example, copper foil a predetermined number of times. In this embodiment, the primary coil **311** and the secondary coil **312** are formed spirally to surround the periphery of the central leg insertion portion **20***c* of the circuit board **20**. In other words, the primary coil **311** and the secondary coil **312** are formed surrounding the central leg portion **321***c* of the first core **321**.

Furthermore, the primary coil **311** and the secondary coil **312** are formed by being divided between plural layers via a via hole in order to increase the number of turns. Specifically, the primary coil **311** is formed by being divided between the two layers of the first layer **22***a* and the second layer **22***b*, and the secondary coil **312** is formed by being divided between the two layers of the third layer **22***c* and the fourth layer **22***d*.

It should be noted that the thickness and width of the patterns of the primary coil **311** and the secondary coil **312** are determined according to the amount of current that flows at the time of transformer operation. For example, the cross-sectional area of the patterns increase when the patterns of the primary coil **311** and the secondary coil **312** are made thick, and thus the direct current resistance component decreases and the amount of current flowing through the patterns increases.

(Transformer)

As illustrated in FIG. **1**A, the transformer **30** in this embodiment includes the core **320** and the winding patterns **310** formed in the circuit board **20**. The drive frequency of the transformer **30** is, for example, about 10 to 500 kHz.

The winding patterns **310** is a coil portion consisting of the primary coil **311** and the secondary coil **312** which are formed in the circuit board **20** as described earlier. The primary side of the transformer **30** is formed by the primary coil **311**, and the secondary side of the transformer **30** is formed by the secondary coil **312**.

The core **320** forms the magnetic path of the magnetic flux created by passing current through the winding patterns **310** (the primary coil **311** and the secondary coil **312**), and causes magnetic coupling of the primary coil **311** and the secondary coil **312**.

As illustrated in FIG. **1**B and FIG. **2**, in this embodiment, the core **320** includes the first core **321** and the second core **322**. As one example, the core **320** is of the EI type, and is formed by joining the substantially E-shaped first core **321** and the substantially I-shaped second core **322** together.

The first core **321** has the first outer leg portion **321***a* formed at one end of the main body portion, the second outer leg portion **321***b* formed at the other end of the main body portion, and the central leg portion **321***c* formed between the first outer leg portion **321***a* and the second outer leg portion **321***b* (i.e., at the center of the main body). In other words, the first core **321** has a pair of outer leg portions (the first outer leg portion **321***a* and the second outer leg portion **321***b*) and the central leg portion **321***c* provided between the pair of outer leg portions.

When attaching the first core **321** to the circuit board **20**, the first outer leg portion **321***a* is inserted through the first outer leg insertion portion **20***a* of the circuit board **20**, the second outer leg portion **321***b* is inserted through the second outer leg insertion portion **20***b* of the circuit board **20**, and the central leg portion **321***c* is inserted through the central leg insertion portion **20***c* of the circuit board **20**.

On the other hand, the second core **322** is a board-shaped core. When putting the first core **321** and the second core **322** together, the tips of the first outer leg portion **321***a* and the second outer leg portion **321***b* of the first core **321** abut the surface of the second core **322**.

The EI type core **320** configured in the above-described manner is attached to the circuit board **20** by inserting the first outer leg portion **321***a* through the first outer leg insertion portion **20***a* of the circuit board **20**, inserting the second outer leg portion **321***b* through the second outer leg insertion portion **20***b*, and inserting the central leg portion **321***c* through the central leg insertion portion **20***c*, so that the circuit board **20** is sandwiched by the first core **321** and the second core **322**.

The first core **321** and the second core **322** are, for example, ferrite cores, and can be formed by mixing manganese oxide, zinc oxide, nickel oxide, or the like, into iron oxide, and sintering at a high temperature of 1000° C. to 1400° C.

(Resin)

The resin **40** is an adhesive for bonding the core **320** of the transformer **30** and the base **10**. An insulating adhesive comprising a silicone resin, or the like, can be used for the resin **40**.

Here, the detailed configuration of the resin **40** will be described using FIG. **4** with reference to FIG. **1**A and FIG. **1**B. FIG. **4** is a perspective view of a configuration of the vicinity of a resin in a lighting device according to Embodiment 1 of the present invention.

As illustrated in FIG. **1**A, FIG. **1**B, and FIG. **4**, the resin **40** bonds together the first core **321** of the core **320** and the base **10**. Specifically, the resin **40** can be inserted from the first outer leg insertion portion **20***a*, and is provided between the lateral face of the first outer leg portion **321***a* of the first core **321** and the surface of the base **10** by being brought into contact with the lateral face of the first outer leg portion **321***a* and the surface of the base **10** in the first outer leg insertion portion **20***a*.

Furthermore, the resin **40** is formed on the surface of the core **320** (the first core **321**) from the first outer leg portion **321***a* to a point up to the second outer leg portion **321***b*. More specifically, the resin **40** is formed on the surface of the core **320** (the first core **321**) from the first outer leg portion **321***a* to a point up to the central leg portion **321***c*. In this manner, adhesive (the resin **40**) is not applied throughout the circuit board **20**, and the resin **40** is formed only on the portions around the first outer leg portion **321***a*. In other words, the resin **40** is not formed in a gap between the circuit board **20** and the base **10**, and the gap forms air space.

In addition, the resin **40** in this embodiment, as illustrated in FIG. **1**B, is also disposed between the bottom face of the first core **321** (the first outer leg portion **321***a*) and the top face of the base **10**. In other words, the resin **40** in this embodiment is provided continuously from the lateral face to the bottom face of the first core **321**.

When bonding together the core **320** and the base **10**, the resin **40** may be applied in advance to a predetermined position in the base **10** before the circuit board **20**, to which the first core **321** and the second core **322** are secured by the spring component **50**, is placed on the base **10**. However, since the opening of the first outer leg insertion portion **20***a* of the circuit board **20** is of a size which allows the resin **40** to be applied via the first outer leg insertion portion **20***a* even after the core **320** is attached to the circuit board **20** as described above, the resin **40** can be applied toward the bottom portion of the first core **321** via the first outer leg insertion portion **20***a*, even after the circuit board **20**, to which the first core **321** and the second core **322** are secured by the spring component **50**, is placed on the base **10**.

It should be noted that, after the resin **40** is applied, the core **320** (first core **321**) and the base **10** can be bonded together by curing the resin **40**.

Furthermore, the resin **40** is provided between the spring component **50** and the base **10**. Specifically, the resin **40** is provided so as to cover a bottom portion of the lateral face of the first core **321** so as to cover the bottom portion of a first arm portion **52***a* of the spring component **50**. With this, the spring component **50** and the base **10** can also be bonded together by the resin **40**.

(Spring Component)

As illustrated in FIG. **1**A and FIG. **1**B, the spring component **50** is a fixing spring (core fixing equipment) for securing the first core **321** and the second core **322** in an integrated manner through spring elastic force. By being clamped together by the spring component **50**, the first core **321** and the second core **322** are attached to the circuit board **20** in such a way that the circuit board **20** is sandwiched by the first core **321** and the second core **322**.

As illustrated in FIG. **1**B and FIG. **2**, the spring component **50** is a clip-type plate spring, and has a plate-like body portion **51**, a pair of plate-like arm portions (the first arm portion **52***a* and a second arm portion **52***b*), and a pair of plate-like holding portions (a first holding portion **53***a* and a second holding portion **53***b*).

The body portion **51** comes into contact with the top surface of the second core **322**, when securing the first core **321**

and the second core **322**. By clamping the first core **321** and the second core **322** together using the body portion **51** and the first holding portion **53***a* and second holding portion **53***b*, the first core **321** and the second core **322** are held in an integrated manner by the spring component **50**.

Each of the pair of the first arm portion **52***a* and the second arm portion **52***b* are connected approximately perpendicularly to different lengthwise ends of the body **51**, and extend toward the base **10** so as to be respectively inserted through the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b* of the circuit board **20**.

Furthermore, in this embodiment, when securing the first core **321** and the second core **322** together using the spring component **50**, the inner face of the first arm portion **52***a* comes into contact with the lateral face of the first leg portion **321***a*, and the inner face of the second arm portion **52***b* comes into contact with the lateral face of the second leg portion **321***b*.

The first holding portion **53***a* and the second holding portion **53***b* are formed by bending the end of the first arm portion **52***a* and the end of the second arm portion **52***b* toward each other. The first holding portion **53***a* and the second holding portion **53***b* come into contact with the bottom face of the first core **321**, when securing the first core **321** and the second core **322** together using the spring component **50**.

Although a metal such as SUS is used for the material of the spring component **50**, the material of the spring component **50** is not limited to metal. Furthermore, the spring component **50** can be formed, for example, by shaping a single metal plate.

(Summary)

As described above, in the lighting device **1** in this embodiment, the base **10** and the lateral face of the first outer leg portion **321***a* of the first core **321** are bonded together in the first outer leg insertion portion **20***a* by the resin **40** which can be inserted from the first outer leg insertion portion **20***a*. Furthermore, the resin **40** is formed only on the surface of the first core **321** from the first outer leg portion **321***a* to a point up to the second outer leg portion **321***b*. In other words, the lateral face of the first outer leg portion **321***a* and the base **10** are bonded together by having the resin **40** inserted from the first outer leg insertion portion **20***a*.

Accordingly, even after the circuit board **20**, to which the core **320** is attached, is placed on the base **10**, the core **320** and the base **10** can be easily bonded together because the resin **40** can be inserted and applied from the first outer leg insertion portion **20***a*. Because, for example, a nozzle for applying the resin **40** can be inserted through the first leg insertion portion **20***a* and the resin **40** can be applied continuously from the first outer leg insertion portion **20***a* to the base **10**, the lighting device **1** can be easily assembled. Furthermore, since bonding is possible after the circuit board **20** is placed on the base **10**, positioning of the circuit board **20** and the base **10** can be performed precisely before bonding together the circuit board **20** and the base **10**.

In addition, in this embodiment, the first core **321** and the second core **322** can be attached to the circuit board **20** by inserting the three leg portions of the first core **321** through the corresponding three through holes (the first outer leg insertion portion **20***a*, the second outer leg insertion portion **20***b*, and the central leg insertion portion **20***c*) of the circuit board **20**, and clamping together the first core **321** and the second core **322** using the spring component **50**, in a state where the circuit board **20** is sandwiched between the first core **321** and the second core **322**.

In this case, when the circuit board **20** is shaken, or when the three leg portions of the first core **321** are inserted through the through holes at the time of manufacturing, there are cases where the legs of the first core **321** and the edges of the through holes of the circuit board **20** come into contact with each other creating chips or cracks in the first core **321**, and thereby causing deterioration of the characteristics of the transformer **30**.

In contrast, in this embodiment, the width of the opening of at least the first outer leg insertion portion **20***a* is of a size which allows application of the resin **40**. With this, it is possible to suppress contact between the first outer leg portion **321***a* of the first core **321** and the edge of the first outer leg insertion portion **20***a*. Therefore, deterioration of the characteristics of the transformer **30** due to chips or cracks in the first core **321** can be suppressed. Furthermore, since the width of the opening of the first outer leg insertion portion **20***a* is large, the insertability of the first core **321** (the first outer leg portion **321***a*) through the first outer leg insertion portion **20***a* can be improved.

Furthermore, in this embodiment, as illustrated in FIG. **1**A and FIG. **1**B, the clearance L**1***a* between the circuit board **20** and the lateral face of the first outer leg portion **321***a* in the first outer leg insertion portion **20***a* is larger than the clearance L**2** between the circuit board **20** and the central leg portion **321***c* in the central leg insertion portion **20***c*.

Accordingly, even after the circuit board, to which the core **320** is attached, is placed on the base **10**, the resin **40** can be easily applied to a predetermined position via the first outer leg insertion portion **20***a*.

Furthermore, in this embodiment, the first core **321** and the second core **322** are secured together by the spring component **50** and attached to the circuit board **20**. As such, in the first outer leg insertion portion **20***a*, it is preferable that the clearance between the circuit board **20** and outer face of the first holding unit **52***a* of the spring component **50** which is inserted through the first outer leg insertion portion **20***a* be made larger than the clearance between the first outer leg portion **321***a* and the inner face of the first arm portion **52***a*.

Accordingly, an opening portion for the first outer leg insertion portion **20***a* can be ensured even when the first core **321** and the second core **322** are secured together by the spring component **50**, and thus the resin **40** can be easily applied via the first outer leg insertion portion **20***a*.

In addition, in this case, as illustrated in FIG. **1**B, it is preferable that the first arm portion **52***a* of the spring component **50** be in contact with the first outer leg portion **321***a* of the first core **321**. In other words, it is preferable that the clearance between the first outer leg portion **321***a* and the inner face of the first arm portion **52***a* be zero.

Accordingly, even if the first arm portion **52***a* of the spring component **50** is inserted through the first outer leg insertion portion **20***a*, it is possible to ensure a maximum size for the width of the opening of the first outer leg insertion portion **20***a*. Therefore, the resin **40** can be more easily applied via the first outer leg insertion portion **20***a*.

Furthermore, in this embodiment, as illustrated in FIG. **1**B, aside from the lateral face of the first core **321** (the first outer leg portion **321***a*), the resin **40** is also disposed between the bottom face of the first core **321** and the top face of the base **10**.

Accordingly, the base **10** and the lateral and bottom faces of the of the first core **321** can be bonded together, and thus the core **320** (the first core **321**) and the base **10** can be bonded together strongly.

As described thus far, according to the lighting device **1** according to this embodiment, easy assembly is possible, changing of transformer electrical characteristics caused by chips or cracks in the core in a high-temperature environment

or a shaky environment is suppressed thereby enabling increased transformer efficiency, and a small lighting device capable of suppressing circuit breakage due to heat stress can be realized.

(Modification 1)

Next, a lighting device **2** according to Modification 1 of Embodiment 1 of the present invention will be described using FIG. **5**A and FIG. **5**B. FIG. **5**A is a plan view of a lighting device according to Modification 1 of Embodiment 1 of the present invention. FIG. **5**B is a cross-sectional view of the lighting device at line A-A' in FIG. **5**A.

In the lighting device **1** in the forgoing embodiment illustrated in FIG. **1**A, the first core **321** and the base **10** are not in contact at the second outer leg insertion portion **20***b*, and the clearance L**1***b* between the circuit board **20** and the lateral face of the second outer leg portion **321***b* in the second outer leg insertion portion **20***b* is smaller than the clearance L**1***a* between the circuit board **20** and the lateral face of the first outer leg portion **321***a* in the first outer leg insertion portion **20***a*.

On the other hand, in the lighting device **2** in this modification, as illustrated in FIG. **5**A and FIG. **5**B, aside from the lateral face of the first outer leg portion **321***a* and the base **10** being bonded together by a first resin **41** in the first outer leg insertion portion **20***a*, the lateral face of the second outer leg portion **321***b* and the base **10** are also bonded together by a second resin **42** in the second outer leg insertion portion **20***b*. In other words, in this modification, each of the pair of outer leg portions (the first outer leg portion **321***a* and the second outer leg portion **321***b*) of the first core **321** and the base **10** are bonded together using two resins (the first resin **41** and the second resin **42**).

Specifically, the first resin **41** is the same as the resin **40** in the forgoing embodiment, and is formed on the surface of the core **320** (the first core **321**) from the first outer leg portion **321***a* to a point up to the central leg portion **321***c*.

Furthermore, the second resin **42** is formed on the surface of the core **320** (the first core **321**) from the second outer leg portion **321***b* to a point up to the first outer leg portion **321***a*. In this modification, the second resin **42** is formed on the surface of the core **320** (the first core **321**) from the second outer leg portion **321***b* to a point up to the central leg portion **321***c*.

In this manner, resin (adhesive) is not applied throughout the circuit board **20**, but formed only on the portions around the two locations of the first outer leg portion **321***a* and the second outer leg portion **321***b*.

Furthermore, in this modification, since the first resin **41** and the second resin **42** are inserted from the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*, respectively, aside from the first outer leg insertion portion **20***a*, the width of the opening of the second outer leg insertion portion **20***b* is also made large.

Specifically, the clearance L**1***b* between the circuit board **20** and lateral face of the second outer leg portion **321***b* in the second outer leg insertion portion **20***b* is made identical as the clearance L**1***a* between the circuit board **20** and the lateral face of the first outer leg portion **321***a* in the first outer leg insertion portion **20***a*, and the width of the opening of the second outer leg insertion portion **20***b* is made large.

In other words, in the same manner as the opening of the first outer leg insertion portion **20***a*, the width of the opening of the second outer leg insertion portion **20***b* is of a size which allows application of the second resin **42** via the second outer leg insertion portion **20***b* even after the circuit board **20**, to which the core **320** (the first core **321**) is attached, is placed on the base **10**, and the clearance L**1***b* is made larger than the clearance L**2** (i.e., the clearance between the circuit board **20** and the central leg portion **321***c* in the central leg insertion portion **20***c*).

Thus, according to the lighting device **2** in this modification, the lateral face of the first outer leg portion **321***a* and the base **10** are bonded together in the first outer leg insertion portion **20***a* by the first resin **41** which can be inserted from the first outer leg insertion portion **20***a*, and the lateral face of the second outer leg portion **321***b* and the base **10** are bonded together in the second outer leg insertion portion **20***b* by the second resin **42** which can be inserted from the second outer leg insertion portion **20***b*. Furthermore, the first resin **41** is formed only on the surface of the first core **321**, from the first outer leg portion **321***a* to a point up to the second outer leg portion **321***b*, and the second resin **42** is formed only on the surface of the first core **321**, from the second outer leg portion **321***b* to a point up to the first outer leg portion **321***a*. In other words, in this modification, the base **10** and the two lateral faces of the first core **321** (the later face of the first outer leg portion **321***a* and the lateral face of the second outer leg portion **321***b*) are bonded together by inserting the two of the first resin **41** and the second resin **42** from the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*, respectively.

Accordingly, the core **320** and the base **10** can be easily bonded together even after the circuit board **20**, to which the core **320** is attached, is placed on the base **10**, as in Embodiment 1, because the first resin **41** and the second resin **42** can be inserted and applied from the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*, respectively. On top of that, since they are fixed at two places, the core **320** (first core **321**) and the base **10** can be more strongly bonded together compared to Embodiment 1.

Furthermore, in this modification too, as illustrated in FIG. **5**B the first resin **41** in the first outer leg insertion portion **20***a* is disposed, not only on the lateral face of the first core **321** (the first outer leg portion **321***a*), but also between the bottom face of the first core **321** and the top face of the base **10**. Furthermore, in this modification, the second resin **42** in the second outer leg insertion portion **20***b* is also disposed, not only on the lateral face of the first core **321** (the second outer leg portion **321***b*), but also between the bottom face of the first core **321** and the top face of the base **10**.

Accordingly, since the lateral face and bottom face of the first core **321** and the base **10** are bonded together at two places on the first core **321**, the core **320** (the first core **321**) and the base **10** can be bonded together more strongly.

Furthermore, as in this modification, by making the width of the openings of the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b* large, it is possible to suppress contact between the first outer leg portion **321***a* and the edge of the first outer leg insertion portion **20***a* and between the second outer leg portion **321***b* and the edge of the second outer leg insertion portion **20***b*. Therefore, compared to the forgoing embodiment, deterioration of the characteristics of the transformer **30** due to chips or cracks in the first core **321** can be further suppressed. In addition, the insertability of the leg portions (the first outer leg portion **321***a* and the second outer leg portion **321***b*) of the first core **321** through the outer leg insertion portions (the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*) of the circuit board **20** can be further improved.

(Modification 2)

Next, a lighting device **3** according to Modification 2 of Embodiment 1 of the present invention will be described

using FIG. **6**. FIG. **6** is a plan view of a lighting device according to Modification 2 of Embodiment 1 of the present invention.

Whereas the first outer leg insertion portion **20***a* is a through hole penetrating through the circuit board **20** in the lighting device **1** in the forgoing embodiment illustrated in FIG. **1**A, in the lighting device **3** in this modification, the first outer leg insertion portion **20***a* is a notch formed by cutting out a portion of the outer edge of the circuit board **20**, as illustrated in FIG. **6**.

Specifically, the first outer leg insertion portion **20***a* is a notch formed by cutting out, in a rectangular shape, a central portion of one side of the circuit board **20** having a rectangular plan view shape. It should be noted that the shape of the notch is not limited to a rectangle.

As described above, according to the lighting device **3** in this modification, the base **10** and the lateral face of the first outer leg portion **321***a* of the first core **321** are bonded together in the first outer leg insertion portion **20***a* by the resin **40** which can be inserted from the first outer leg insertion portion **20***a*, in the same manner as in the lighting device **1** in the forgoing embodiment. Furthermore, the resin **40** is formed only on the surface of the first core **321**, from the first outer leg portion **321***a* to a point up to the second outer leg portion **321***b*. In other words, the lateral face of the first outer leg portion **321***a* and the base **10** are bonded together by having the resin **40** inserted from the first outer leg insertion portion **20***a*.

Accordingly, even after the circuit board **20**, to which the core **320** is attached, is placed on the base **10**, the core **320** and the base **10** can be easily bonded together because the resin **40** can be inserted and applied using the first outer leg insertion portion **20***a*.

In addition, in this modification, the first outer leg insertion portion **20***a* is a notch formed by making a cut-out in one side of the circuit board **20**.

Accordingly, since the top portion of the lateral face of the first outer leg portion **321***a* is open even after the first outer leg portion **321***a* of the first core **321** is inserted through the first outer leg insertion portion **20***a*, it becomes easy to insert a nozzle for applying the resin **40** through the first outer leg insertion portion **20***a*. For example, the nozzle can be inserted from the side instead of from above the first outer leg insertion portion **20***a*. Therefore, the resin **40** can be more easily applied compared to when the first outer leg insertion portion **20***a* is a through hole.

Furthermore, by making the first outer leg insertion portion **20***a* a notch, contact between the first outer leg portion **321***a* of the first core **321** and the edge of the first outer leg insertion portion **20***a* can be further suppressed compared to Embodiment 1. Therefore, deterioration of the characteristics of the transformer **30** due to chips or cracks in the first core **321** can be further suppressed. In addition, the insertability of the first core **321** (the first outer leg portion **321***a*) through the first outer leg insertion portion **20***a* can be further improved.

Furthermore, by making the first outer leg insertion portion **20***a* a notch, it is possible to increase the mounting area for electronic components in the circuit board **20** compared to when the first outer leg insertion portion **20***a* is a through hole.

It should be noted that although the second outer leg insertion portion **20***b* is a through hole, the first outer leg insertion portion **20***a* is a notch, and the first core **321** and the base **10** are bonded together by the resin **40** only in the first outer leg insertion portion **20***a* in the lighting device **3** illustrated in FIG. **6**, both the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b* may be notches, and the first core **321** and the base **10** may be bonded together by the first resin **41** and the second resin **42** in the two locations of the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*, respectively, as in a lighting device **4** illustrated in FIG. **7**.

With this, the core **320** (the first core **321**) and the base **10** can be bonded together more strongly compared to the lighting device **3** illustrated in FIG. **6**.

Furthermore, in the case of the configuration illustrated in FIG. **7**, the first resin **41** and the second resin **42** can be applied by inserting a nozzle from the open area of the notches of the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*. In other words, the nozzle can be inserted by being slid from the side of the notch instead of from above the first outer leg insertion portion **20***a*.

Accordingly, even if the width of the respective notches of the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b* is smaller than the width of the opening of the first outer leg insertion portion **20***a* illustrated in FIG. **1**A, the first resin **41** and the second resin **42** can still be applied via the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*. As a result, the mounting area for electronic components in the circuit board **20** can be increased compared to the lighting device **3** illustrated in FIG. **6**.

(Modification 3)

Next, a lighting device **5** according to Modification 3 of Embodiment 1 of the present invention will be described using FIG. **8**. FIG. **8** is a plan view of a lighting device according to Modification 3 of Embodiment 1 of the present invention.

In the lighting device **5** in this embodiment, first outer leg insertion portion **20***a* is a notch formed by cutting out a portion of the outer edge of the circuit board **20** in the same manner as in the lighting device **3** in Modification 2. However, whereas the central portion of one side of the circuit board **20** is cut out in the lighting device **3** in Modification 2, a corner portion of the circuit board **20** is cut out in the lighting device **5** in this modification, as illustrated in FIG. **8**.

Specifically, the first outer leg insertion portion **20***a* in this modification is a notch formed by cutting out one of the corner portions of the circuit board **20** having a rectangular plan view shape, and has a shape obtained by making a cut out from one point of one side of the circuit board **20** up to the corner portion. In other words, the plan view shape of the circuit board **20** before forming the first outer leg insertion portion **20***a* (notch) is rectangular.

It should be noted that, although the first outer leg insertion portion **20***a* is cut out in a rectangular shape in this modification, the shape of the cut-out is not limited to a rectangle.

Thus, the lighting device **5** in this modification can obtain the same advantageous effects as the lighting device **3** in Modification 2. In other words, while increasing the mounting area for electronic components in the circuit board **20**, it is possible to easily apply the resin **40** using the first outer leg insertion portion **20***a* even after the circuit board **20**, to which the core **320** is attached, is placed on the base **10**. Furthermore, deterioration of the characteristics of the transformer **30** due to chips or cracks in the first core **321** can be suppressed, and insertability of the first core **321** (the first outer leg portion **321***a*) through the first outer leg insertion portion **20***a* can be improved.

It should be noted that although the second outer leg insertion portion **20***b* is a through hole, the first outer leg insertion portion **20***a* is a notch, and the first core **321** and the base **10** are bonded together by the resin **40** only in the first outer leg insertion portion **20***a* in the lighting device **5** illustrated in FIG. **8**, both the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b* may be notches, and the first core **321** and the base **10** may be bonded together by the first resin **41** and the second resin **42** in the two locations

of the first outer leg insertion portion **20***a* and the second outer leg insertion portion **20***b*, respectively, as in a lighting device **6** illustrated in FIG. **9**.

With this, the core **320** (the first core **321**) and the base **10** can be bonded together more strongly compared to the lighting device **5** illustrated in FIG. **8**.

Furthermore, in the case of the configuration illustrated in FIG. **9**, the first outer leg insertion portion **20***a* cuts out the corner portion of the circuit board **20**, thus allowing the unusable area in the circuit board **20** to be reduced. Furthermore, since the second outer leg insertion portion **20***b* cuts out a portion of one side of the circuit board **20**, the second resin **42** can be applied via the second outer leg insertion portion **20***b* even if the width of the cut-out of the second outer leg insertion portion **20***b* is smaller than the width of the opening of the first outer leg insertion portion **20***a* illustrated in FIG. **1**A. As a result, the mounting area for electronic components in the circuit board **20** can be increased compared to the lighting device **5** illustrated in FIG. **8**.

Embodiment 2

Next, a light fixture **100** according to Embodiment 2 of the present invention will be described using FIG. **10** and FIG. **11**. FIG. **10** is a cross-sectional view of a light fixture according to Embodiment 2 of the present invention. FIG. **11** is a block diagram illustrating a configuration of a light fixture according to Embodiment 2 of the present invention.

The light fixture **100** according to this embodiment is a headlight in a vehicle such as an automobile, and so on, and, as illustrated in FIG. **10**, includes a housing **110**, an HID lamp **120** which is a light source housed inside the housing **110**, an igniter **130** with integrated socket for attaching the HID lamp **120**, and the lighting device **1** for controlling the lighting of the HID lamp **120**.

The lighting device **1** is attached to the bottom of the housing **110**, and is connected with the igniter **130** by a harness **140**. The lighting device **1** supplies predetermined power to the HID lamp **120** via the igniter **130**. It should be noted that, although the lighting device **1** according to Embodiment 1 illustrated in FIG. **1**A and FIG. **1**B is used here, the lighting devices **2** to **6** in the modifications may be used as the lighting device.

As illustrated in FIG. **11**, in the light fixture **100**, the lighting device **1** includes, as a power supply circuit unit, an inverter **150** and a DC/DC converter **160**, and is connected to a power supply **180** (for example, a direct current power supply such as a battery). The direct current power supplied from the power supply **180** undergoes power conversion by the DC/DC converter **160** and the inverter **150**, and the output of the inverter **150** is supplied to the igniter **130** via the harness **140**.

The igniter **130** generates a high voltage of several tens of kV for starting up the HID lamp **120**, and causes the HID lamp **120** to start up by applying the high voltage to the HID lamp **120**.

The inverter **150** is, for example, a full-bridge inverter which converts the direct current output voltage of the DC/DC converter **160** to a low-frequency square wave. Prior to the start up of the HID lamp **120**, the inverter **150** supplies the igniter **130** with a voltage which causes the generation of a starting pulse.

The DC/DC converter **160** is, for example, a flyback DC/DC converter which raises or lowers the direct current voltage from the power supply **180** to the voltage required by the HID lamp, by changing the ON time, drive frequency, or the like, of a switching element. The DC/DC converter **160** includes the transformer **30** in Embodiment 1.

The control unit **170** controls the DC/DC converter **160** so that the output power of the lighting device **1** is at the target power.

As described above, the lighting device **1** to **6** in the foregoing embodiments can be used in a light fixture, or the like, of a vehicle, or the like.

Embodiment 3

Next, a vehicle **200** according to Embodiment 3 of the present invention will be described using FIG. **12**. FIG. **12** is a diagram showing an outline configuration of a vehicle according to Embodiment 3 of the present invention.

As shown in FIG. **12**, the vehicle **200** according to this embodiment is, for example, a four-wheeled automobile, and includes a vehicle body **210** and headlights which are light fixtures **100** attached to the vehicle body **210**.

In recent years, engine room space is being reduced to secure more passenger room inside the automobile or for weight-reduction aimed at improving fuel consumption Consequently, aside from the increase in temperature inside the engine room, the lighting device which controls the lighting of a light source is placed nearer the engine which releases a large amount of heat, and thus there is a demand for a smaller lighting device that is more capable of stably lighting a light source even in a high-temperature environment.

The lighting devices **1** to **6** in the foregoing embodiments allow for easy assembly, are small, and exhibit minimal change in electrical characteristics even in a high-temperature environment, and are thus useful in a light fixture of a vehicle such as an automobile.

(Other Modifications, and So on)

Although lighting devices, light fixtures, and vehicles according to aspects of the present invention have been described based on embodiments and modifications, the present invention is not limited to the above-described embodiments and modifications.

For example, in the forgoing embodiments and modifications, the spring component **50** is not limited to the configuration illustrated in FIG. **2**, and a substantially M-shaped spring component **50**A such as that illustrated in FIG. **13**A or a spring component **50**B which is in the general shape of a leftward-facing U (inverted C) such as that illustrated in FIG. **13**B may be used.

The spring component **50**A has a plate-like body portion **51**A that is curved so as to project toward the core **320**, the first arm portion **52***a*, the second arm portion **52***b*, the first holding portion **53***a*, and the second holding portion **53***b*. As with the spring component **50**, with the spring component **50**A, the first core **321** and the second core **322** are held together by being sandwiched between the body portion **51**A and the first holding portion **53***a* and second holding portion **53***b*.

The spring component **50**B is configured of a plate-like body portion **51**B that comes into contact with the second core **322**, a holding portion **53**B that comes into contact with the first core **321**, and an arm portion **52**B connecting the body portion **51**B and the holding portion **53**B. With the spring component **50**B, the first core **321** and the second core **322** are held together by being sandwiched between the body portion **51**B and the holding portion **53**B.

Furthermore, in the forgoing embodiments and modifications, the core **320** is not limited to the EI type such as that illustrated in FIG. **2**, and an EIR type core **320**A such as that illustrated in FIG. **14**A or a CI type core **320**B such as that illustrated in FIG. **14**B may be used.

The core **320**A includes a first core **321**A and the second core **322**. The first core **321**A has a first outer leg portion and a second outer leg portion which have a rectangular cross-sectional shape, and a central leg portion which has a circular cross-sectional shape.

The core **320**B includes a substantially C-shaped (U-shaped) first core **321**B and the I-shaped second core **322**. In other words, a core having only a pair of outer leg portions and no central leg portion may be used for the first core.

Furthermore, a core of the EE type, a PQI type, an RM type, or the like may be used for the core **320**, that is, the shapes of the plural cores to be combined are varied. Moreover, by adjusting the length of the gap between the outer leg portions and the central leg portion of the core, the inductance value can be adjusted. It should be noted that combining cores with the same shape allows for the use of the same die, thereby allowing die cost to be reduced.

Furthermore, in the forgoing embodiments and modifications, the circuit board **20** is not limited to the configuration illustrated in FIG. **3**A and FIG. **3**B, and a circuit board **20**A such as that illustrated in FIG. **15**A or a circuit board **20**B such as that illustrated in FIG. **15**B may be used.

For example, the circuit board **20**A is different from the circuit board **20** in terms of the layering order of a first layer **22***a* to a fourth layer **22***d*. Here, each of the first layer **22**A and the fourth layer **22***d* is formed on a different one of the two principal surfaces of a core substrate **21**, and the third layer **22***c* and the second layer **22***b* are formed covering the first layer **22***a* and the fourth layer **22***d*, respectively.

Furthermore, in the circuit board **20**B, each of the second layer **22***b* and the third layer **22***c* is formed on a different one of the two principal surfaces of the core substrate **21**, and the first layer **22***a* and the fourth layer **22***d* are formed covering the third layer **22***c* and the second layer **22***b*, respectively.

Furthermore, in the forgoing embodiments and modifications, the primary coil **311** and the secondary coil **312** of the winding patterns **310** formed on the circuit board **20** are not limited to the configuration illustrated in FIG. **3**A, and a primary coil **311**A and a secondary coil **312**A of a pattern such as that illustrated in FIG. **16**A, a primary coil **311**B and a secondary coil **312**B of a pattern such as that illustrated in FIG. **16**B, or a primary coil **311**C and a secondary coil **312**C of a pattern such as that illustrated in FIG. **16**C may be used.

Furthermore, although the circuit board **20** is mufti-layered in the forgoing embodiment and modifications, the circuit board **20** may be made from a single layer. In this case, if the winding patterns (primary coil and secondary coil) formed on the circuit board are magnetically coupled via the core **320**, the winding patterns function as an inductance.

Furthermore, although the transformer **30** uses the winding patterns **310** formed on the circuit board **20** by patterning in the forgoing embodiments and modifications, a transformer which is configured by wrapping copper wires, or the like, around a bobbin may be used.

Furthermore, although an HID lamp is used as a light source in the forgoing embodiments and modifications, the light source may be a solid-state light-emitting element such as a light emitting diode (LED) or an organic electroluminescent (EL) element. In other words, the lighting device **1** may be configured to control the lighting of a semiconductor light-emitting element, such as an LED, as a light source (load).

Forms obtained by various modifications to the exemplary embodiments and modifications that can be conceived by a person of skill in the art as well as forms realized by arbitrarily combining structural components and functions in the exemplary embodiments and modifications which are within the scope of the essence of the present invention are included in the present invention.

The invention claimed is:

1. A lighting device comprising:
a circuit board placed on a base; and
a transformer provided in the circuit board,
wherein the transformer includes a winding pattern and a core, the winding pattern being formed on the circuit board, and the core having an outer leg portion,
the circuit board has an outer leg insertion portion through which the outer leg portion of the core is inserted,
the circuit board and the base have therebetween a gap which is air space, and
the base and at least a lateral face of the outer leg portion are bonded together by a first resin that is insertable from the outer leg insertion portion.

2. The lighting device according to claim **1**,
wherein the outer leg portion consists of a pair of outer leg portions,
the outer leg insertion portion consists of a pair of outer leg insertion portions through which the pair of outer leg portions are respectively inserted, and
the first resin bonds together the base and a surface of one outer leg portion of the pair of outer leg portions, and is disposed on a surface of the core, from the one outer leg portion to a point up to an other outer leg portion of the pair of outer leg portions.

3. The lighting device according to claim **2**,
wherein the core has a central leg portion located between the pair of outer leg portions, and
the first resin is disposed on the surface of the core, from the one outer leg portion to a point up to the central leg portion.

4. The lighting device according to claim **2**,
wherein the base and a lateral face of the other outer leg portion are bonded together by a second resin that is insertable from one of the pair of outer leg insertion portions which corresponds to the other outer leg portion, and
the second resin is disposed on the surface of the core, from the other outer leg portion to a point up to the one outer leg portion.

5. The lighting device according to claim **1**,
wherein the outer leg insertion portion is a hole penetrating through the circuit board.

6. The lighting device of claim **5**, wherein the hole has a rectangular plan view shape, and a gap is present between the lateral face of the outer leg portion that has been inserted through the hole and a long side of the hole which is opposite the lateral face.

7. The lighting device according to claim **1**,
wherein the outer leg insertion portion is a notch formed by cutting out a portion of an outer edge of the circuit board.

8. The lighting device according to claim **7**,
wherein the notch is formed by cutting out a corner portion of the circuit board.

9. The lighting device according to claim **1**,
wherein the first resin is further disposed between a bottom face of the core and a top face of the base.

10. A light fixture comprising:
the lighting device according to claim **1**;
a housing; and
a light source housed inside the housing and whose lighting is controlled by the lighting device.

11. A vehicle comprising:
the light fixture according to claim **10**; and
a vehicle body.

12. The lighting device of claim **1**, wherein the first resin is an adhesive comprising silicone resin.

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